CHAMP Gravity Field Model UCPH2003

Eva Howe, L. Stenseng, C. C. Tscherning

Department of Geophysics, University of Copenhagen E-mail: eva@gfy.ku.dk

Abstract

The German CHAlleging Minisatellite Payload (CHAMP) was launched in July 2000. It carries a GPS reciever and a three-axes accelerometer. From GPS meassurements a precise orbit of the satellite in August 2001 has been determined by DEOS at TU Delft. With these orbits and pre-processed accelerometer data it has been possible to determine a global gravity field model to degree and order 90, UCPH2003. The gravity field model has been determined using least squares collocation and by considering energy conservation.
Comparison has been made with Arctic gravity data, Eigen-2 and a previous gravity model of ours, UCPH2002_04. The Arctic gravity data is derived from airborne, surface and submarine data.

Energy conservation

An energy conservation method has been applied to data from august 2001. We have used 'Precise Orbit' data from DEOS, which include position and velocity of the satellite, as well as accelerometer measurements.
For the determination of the gravity potential at satellite altitude, the kinetic energy of the satellite must be computed, and external forces must be taken into account. The external forces are tidal potential of the Sun, V_s, Moon, V_m, and friction. The rotation of the earth's potential in the inertial frame must also be taken into account. By subtracting the Earths normal potential U and an integration constant E_0, we find the potential difference;

$$T_{sat} = \frac{1}{2}v^2 - V_s - V_m - \omega(xv_y - yv_x) - \int \vec{v} \cdot \vec{a} dt - U - E_0$$

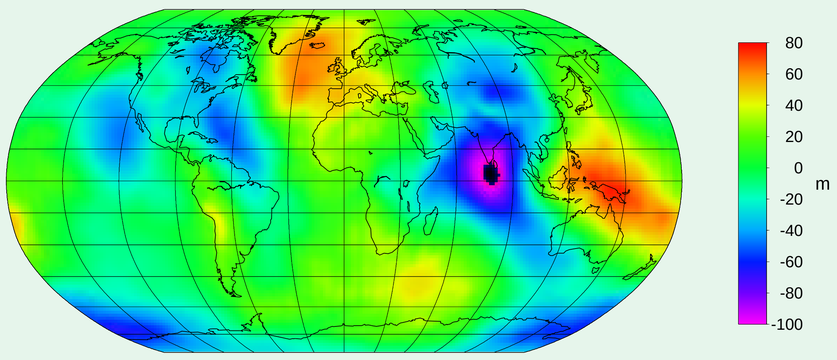

Figure 1: UCPH2003 Geoid heights in metre.

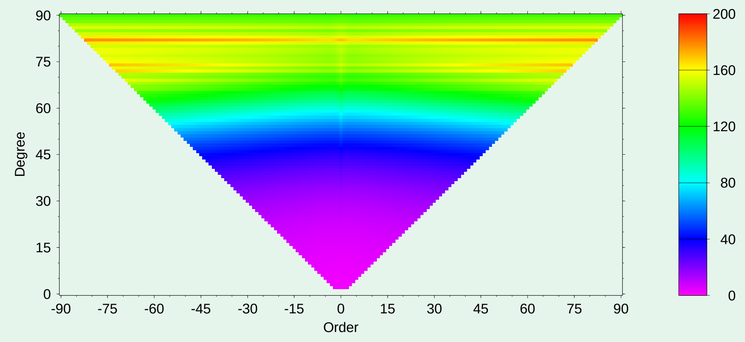

Figure 2: Error estimate for UCPH2003. Scale is in units of 10^{-11}.

Determination of spherical harmonic coefficients

To make the residual potential statistically more homogeneous EGM96 to degree and order 24 was subtracted. The residual potential values are then up-/downwards continued to a common height of 440 km above the ellipsoid.
The covariance of the residual potential is shown in Figure 3. From this the correlation distance is found, which is used in the determination of a grid with 0.5^o spacing. The spherical harmonic coefficients and their associated errors was determined by 'Fast Spherical Collocation'. EGM96 to degree and order 24 is then added to get a complete set of spherical harmonic coefficients.

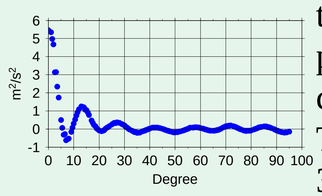

Figure 3: Covariance function of the residual potential.

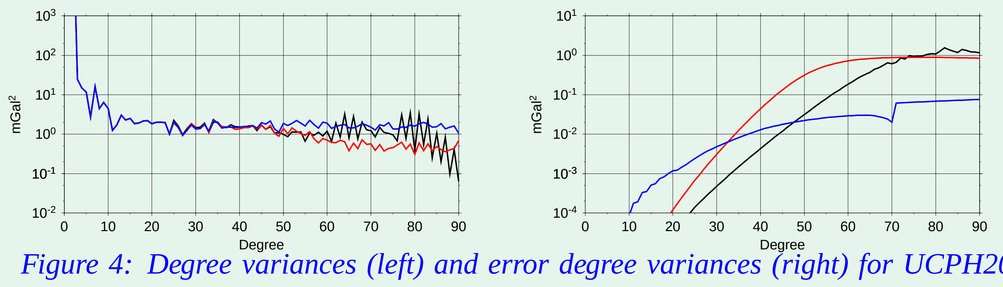

Figure 4: Degree variances (left) and error degree variances (right) for UCPH2003 (black), EGM96 (blue) and EIGEN-2 (red)

Degree variances and error degree variances of our model are compared with EGM96 and EIGEN-2, see Figure 4. It is seen by inspection of Figure 4 that above degree 60 there is no or little information left in UCPH2003 and EIGEN-2. Furthermore it is seen that below degree 40 UCPH2003 is expected to improve EGM96.

Comparison with Arctic gravity data

To verify UCPH2003 it is compared to Arctic gravity data. The same comparison has been made for EIGEN-2 and EGM96. An area in Northwest Greenland has been chosen, 75^o-78^oN and 43^o-53^oW. In this area the three gravity models do not agree. The comparison has been made to degree and order 60. It can be seen in Table 1 that UCPH2003 fits better to the Arctic data than EIGEN-2 and EGM96.

	UCPH2003	EIGEN-2	EGM96
Mean	-1.2 mGal	-6.6 mGal	-4.6 mGal
St. Dev.	13.6 mGal	15.8 mGal	17.8 mGal

Table 1: Comparison between Arctic gravity data and UCPH2003, EIGEN-2 and EGM96.

Evaluation of UCPH2003

The model has been compared to a previous model of ours UCPH2002_04 to degree 90, see Figure 5. This model was calculated using 'Rapid Science Orbits'. These orbits have larger error and a larger time interval than the 'Precise Orbits' used in UCPH2003. For the determination of the non-conservative forces only the along-track acceleration was used in UCPH2002_04. We also found an error in the accelerometer file from August 16th, 2001. This day is included in UCPH2002_04 but not in UCPH2003.

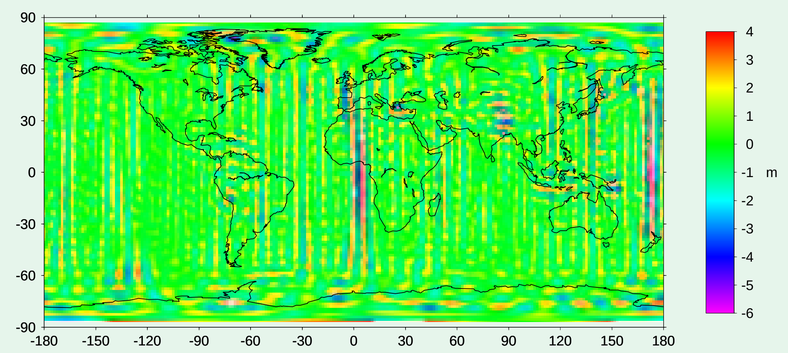

Figure 5: Differences between UCPH2002_04 and UCPH2003.

The largest differences are due to orbit errors and the error of August 16th, 2001. The mean difference between the two models is 2.3 cm and the standard deviation is 1.35 m.

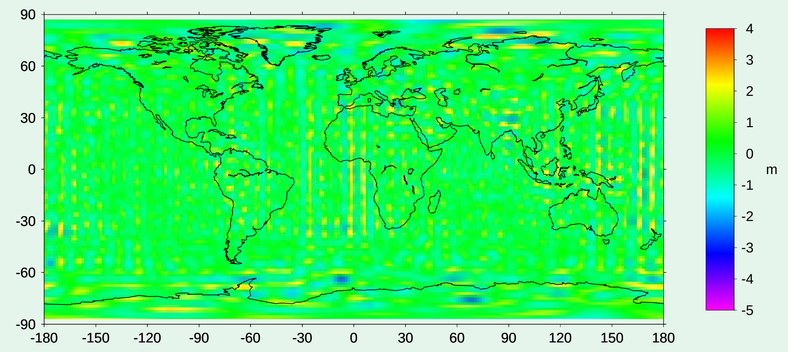

Figure 6: Differences between EIGEN-2 and UCPH2003.

The model has also been compared to EIGEN-2 to degree 60. The difference between geoide heights computed from EIGEN-2 and UCPH2003 respectively are shown in figure 6. The mean difference between the two models is -0.37 cm and the standard deviation is 79,7 cm.

Acknowledgment:

Thanks to J. Van den IJssel DEOS for Precise Orbits and quaternion files. Thanks to the national survey and cadastre (KMS) of Denmark for Arctic gravity data. They are available at NIMA's homepage: www.nima.mil/GandG. This poster is a contribution to the SAGRADA project sponsored by The Danish Science Research Council.

The Gravity Field:

The spherical harmonic coefficients of the Gravity Field UCPH2003 is available at http://www.gfy.ku.dk/∼eva/en/sagrada.php

Contacts:

Eva Howe or C. C. Tscherning
Department of Geophysics
Juliane Maries Vej 30
Dk-2100 Copenhagen Oe
E-mail: eva@gfy.ku.dk or cct@gfy.ku.dk